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The small mammal fauna in a hedge of north-eastern Bavaria

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Abstract

Investigated the small mammal fauna of a hedge in north-eastern Bavaria in 1988. Between March and December 5 species of rodents and 4 species of insectivores were caught by live trapping. Abundance and species diversity varied during the year with a peak in autumn. Compared to forests, rodent density was very high. The most abundant species was *Apodemus sylvaticus* (more than 300 individuals ha^{-1}). Captures per trap were highest in traps in dense vegetation and along the southern rim of the hedge. There was an extensive exchange of individuals between adjacent hedges.

Introduction

Hedges are well known elements within the agriculturally used landscapes of Europe. Hedges are not only important for the surrounding farmland, but provide habitats for a large variety of animals and plants and may serve as corridors between isolated woodlots (Hobbs 1992). Therefore hedges help to conserve wildlife within areas of industrialized agriculture. Despite this importance, the information about the fauna of hedges is quite limited (Pollard and Relton 1970; Rotter and Kneitz 1977; Tischler 1948; Turcek 1958; Zwölfer et al. 1984), especially concerning quantitative data about density and density fluctuations of a particular group. The present report describes species composition and abundance of a small mammal community in a hedge of north-eastern Bavaria.

Materials and methods

We investigated a hedge of an age of more than 30 years near Bayreuth (Bavaria, Upper Franconia). The hedge (HH in Tab. 1 and Fig. 4) covered approximately 2,500 m^2 (250 m long and 8 to 12 m wide) and was oriented from east to west. Dominant woody plant species within the hedge were oak (*Quercus robur*), ash-tree (*Sorbus aucuparia*) and maple (*Acer campestre*) trees, surrounded by thickets of sloe (*Prunus spinosa*), elder (*Sambucus nigra*), hawthorn (*Crataegus oxycanthes*) and wild rose (*Rosa* spec.). Several smaller hedges were found at different distances to this hedge, separated from each other by cultivated fields (Fig. 4). For a general description of hedges in northern Bavaria, see Reif (1983).

From the end of March to the beginning of December 1988, intensive trapping was conducted using 172 Longworth lifetraps (Chitty and Kempson 1949) arranged in a grid of 3 by 5 meters. A mixture of oat, fat and plant oil was provided as food and dry shavings served as insulation material. Excluding the period from 21. July to 4. August, traps were set every week for three consecutive days. No prebaiting preceded the trapping periods. Traps were checked every morning. All captured rodents were marked individually by ear tags using coloured plastic pearls attached to the ears by a nylon thread. For every individual weight, sex, reproductive condition, as well as the trap position in the hedge were recorded. Occasionally trapped insectivores were not marked individually.

According to the density of trees, bushes and different plant species in the undergrowth, the vegetation around each trap was classified as dense, intermediate or open.

To collect information on movements of small mammals between neighbouring hedges, additional traps were set in six adjacent hedges. The number of traps as well as the date, when the trapping period was started are given in table 1. Trapping was completed in all hedges at the beginning of December.

As all rodents were marked, we were able to analyse the data by capture-recapture models (Lebreton et al. 1992). We compiled capture histories for individuals by pooling all data of a month. We used the program JOLLY (Pollock et al. 1990) to estimate the population size within a month, the probability phi(i) that an animal present within hedge at month i will also be present at month i+1 as well as the probability B(i), the recruitment of new individuals to the hedge in the interval i to i+1 and alive at month i+1. For simplicity we call phi survival, but one should be aware that it includes two factors: mortality and emigration. B, called recruitment, includes reproduction and immigration.

Results

Table 1 shows the number of animals and diversity of small mammals trapped in the different hedges during the study period. For insectivores only presence or absence is indicated. The dominant rodent species was *A. sylvaticus*.

Between March and December the number of individuals as well as the species composition of the rodent community showed a prominent seasonal pattern (Fig. 1). While in the beginning of June only 3 animals were caught, a total of 77 individuals belonging to 4 different species (*A. sylvaticus, A. flavicollis, C. glareolus, M. agrestis*) was trapped during three consecutive days in late October. The seasonal pattern is somewhat different among species (Fig. 1). *A. sylvaticus* and *C. glareolus* were present between March and October. But *A. sylvaticus* had its population peak in October, whereas *C. glareolus* had its peak in August/September (Figs. 2, 3). In both species, population increase was mainly due to an increased recruitment and not an increased survival (Figs. 2, 3). Mean survival of *A. sylvaticus* is lower than survival of *C. glareolus* (0.47 versus 0.78). During the peak in autumn population size of *A. sylvaticus* within the main hedge was 77 individuals (density more than 300 individuals ha^{-1}). Maximum density of *C. glareolus* was 88 individuals ha^{-1}.

Table 1. **Species and number of trapped individuals in our main hedge (HH) and 6 adjacent hedges (H1–H6; see also Fig. 4)**

For insectivores, * indicates the presence of a species. Numbers in parentheses refer to animals that were first marked in a different hedge. The start of the trapping period is also given in the table

	HH	H1	H2	H3	H4	H5	H6
Apodemus sylvaticus	147	25	36	12	5	2	3
	(19)	(8)	(14)		(3)	(6)	(1)
Clethrionomys glareolus	38	13	7	8			
	(5)	(2)	(4)				
Apodemus flavicollis	32	5	4		3		
	(4)	(5)				(1)	
Microtus agrestis	16				1		1
					(2)		
Mus musculus	4						
Sorex araneus	*	*					
Sorex minutus	*	*					
Crocidura leucodon	*						*
Talpa europaea	*						
Number of traps	172	10	10	5	3	3	3
Start of period	30.3	29.4	29.4	7.7	23.9	23.9	23.9

Similar to *A. sylvaticus, A. flavicollis* and *M. agrestis* had their population peaks in autumn. But these two species were never or only rarely trapped during summer (Fig. 1).

The total number of captures per trap was not uniform throughout the hedge, but was influenced by the location (northern hedge rim, hedge centre, southern hedge rim) and the

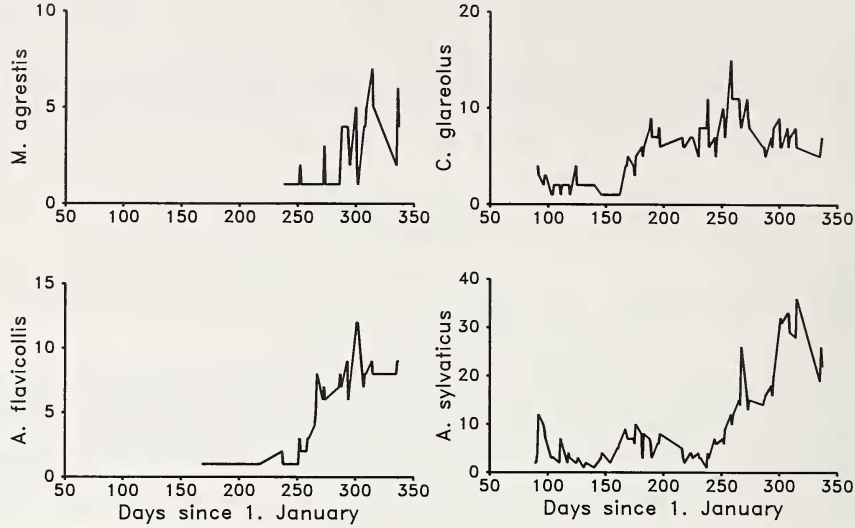

Fig. 1. Daily captures of the four most abundant rodent species

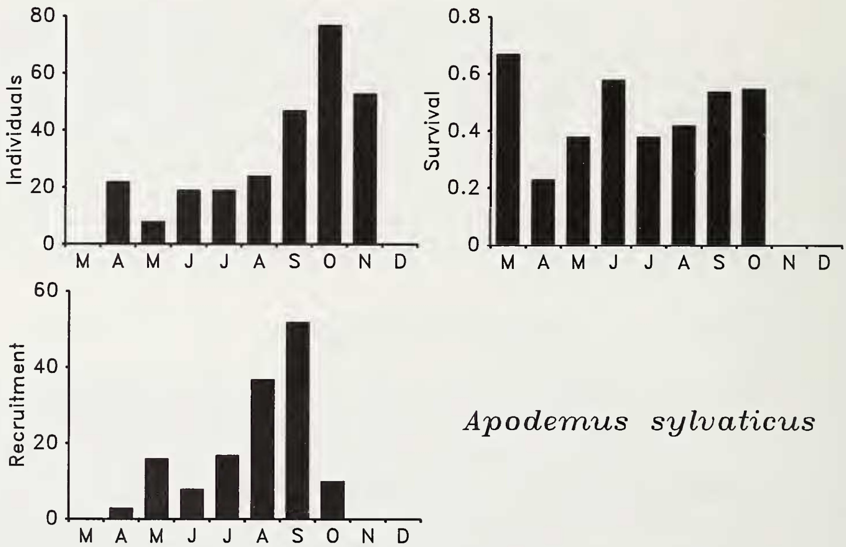

Fig. 2. Number of individuals, survival and recruitment of *A. sylvaticus* as estimated by the capture-recapture program JOLLY

vegetation cover (dense, intermediate, open). Table 2 presents the mean number of captures during the whole trapping period classified according to vegetation cover and position within the hedge. A two-way ANOVA revealed that both factors had significant influences on the effectiveness of a trap (vegetation cover $F = 9.9$; position $F = 34.6$; $P < 0.001$ in both cases). No significant interaction between vegetation cover around the trap and trap position was found ($F = 1.75$; $P = 0.14$).

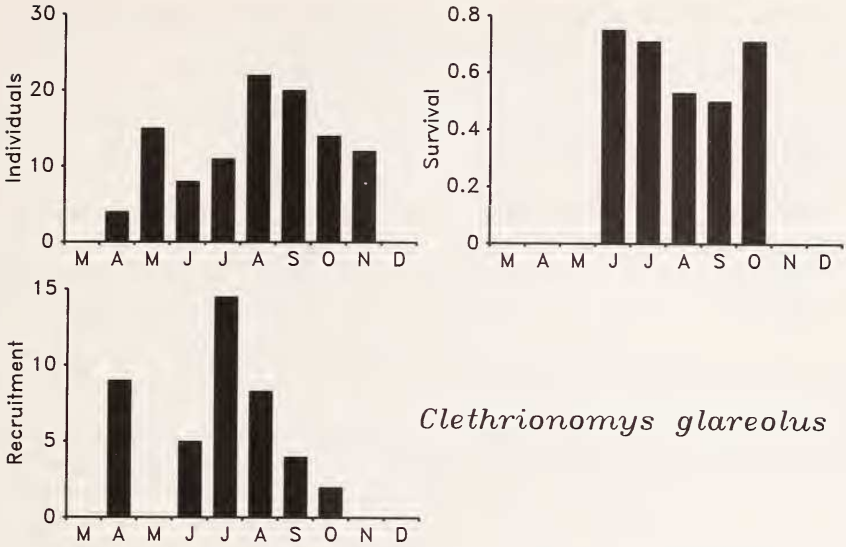

Fig. 3. Number of individuals, survival and recruitment of *C. glareolus* as estimated by the capture-recapture program JOLLY

Out of 362 marked individuals (237 marked in our main hedge and 125 marked in the other hedges), 62 (= 17 %) are known to have moved from the hedge, where they had first been captured, into one of the surrounding hedges (Fig. 4; Tabs. 3, 4). Proportions were not different among species ($Chi^2 = 1.4$; $P < 0.2$), with a significant preponderance of males in *A. sylvaticus* (Tab. 3). Average weights indicate that mainly adults are involved in these movements (Tab. 4). According to the trapping records, some individuals appeared at least in four neighbouring hedges. Only 2 of these individuals returned to the hedge, where they had been caught the first time.

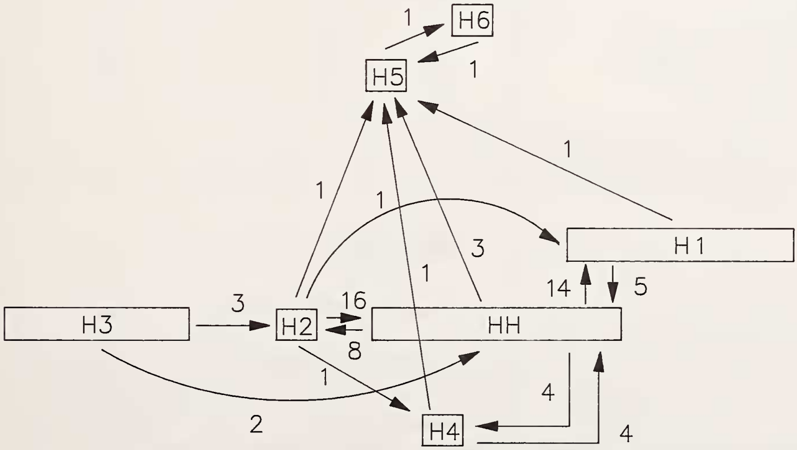

Fig. 4. Known movements of individuals among the hedges. The distance between H4 and H6 is 600 m

Table 2. Mean number of captures per trap during the whole period classified according to trap location and vegetation cover

	N_T	mean	SD
Trap location			
Northern rim	50	6.7	4.0
Centre	72	7.7	7.1
Southern rim	50	16.6	6.6
Vegetation cover			
Dense	82	13.0	8.1
Intermediate	72	7.2	6.0
Open	18	7.7	4.1

N_T = number of traps; SD = standard deviation.

Table 3. Sex ratio of all marked individuals (I) and individuals which are known to have moved from the hedge, where they were first captured, to one of the surrounding hedges (II)

		I	II	Chi^2-Test
Apodemus sylvaticus	male	134	30	$Chi^2 = 5.8$
	female	96	9	$P = 0.016$
	% males	58	77	
Clethrionomys glareolus	male	38	8	$Chi^2 = 0.61$
	female	28	3	$P > 0.2$
	% males	58	73	
Apodemus flavicollis	male	20	5	$Chi^2 = 0.0$
	female	24	5	$P > 0.2$
	% males	45	50	

Table 4. Mean weight (in g) of all marked individuals and of the individuals which are known to have moved of one of the surrounding hedges

	N	Weight	SD	N	Weight	SD
Apodemus sylvaticus	230	18.5	4.7	39	22.1	4.5
Clethrionomys glareolus	66	17.4	4.0	11	20.2	3.8
Apodemus flavicollis	44	26.1	4.5	10	28.3	3.0
Microtus agrestis	18	18.3	4.7	2	22.5	0.7
Mus musculus	4	14.5	1.3			

N = sample size; SD = standard deviation.

Discussion

At present, only limited data on the small mammalian fauna of hedges are available. Besides the species caught during the present study, two additional rodents (*Muscardinus avellanarius, Glis glis*) and three insectivores (*Neomys fodiens, Neomys anomalus, Crocidura suaveolens*) were trapped in hedges at two localities in north-eastern Bavaria (Weisel unpubl.). However, similar results on the occurrence of small mammalian species in hedges were found by Tischler (1948) in northern Germany, Turcek (1958) in Slowenia, Pollard and Relton (1970) and Eldrige (1971) in England. Additional species listed by these authors are *Rattus norvegicus, Micromys minutus* and *Microtus arvalis*.

In addition to the biogeographic available species pool, hedge size, hedgerow management, type of the surrounding area (e.g. arable farmland, forest, wetland) and perhaps interspecific competition (ANDRZEJEWSKI and OLSZEWSKI 1963; BOITANI et al. 1985; GLIWICZ 1984; MONTGOMERY 1980) may influence density and species composition in a particular hedge. The different capture rates of traps indicate how small-scale microhabitat conditions affect the distribution of small mammals in hedgerows. Vegetation cover may be a reliable measure of shelter for foraging mammals, whereas the position within the hedge may be a measure of microclimatic conditions, because the southern hedge rim shows by far the highest activity of small mammals. We have, however, no ideas about the distribution of food within the hedge. Perhaps the southern hedge rim may have better food resources compared to the centre or northern rim of the hedge. Especially herbaceous plants were more common along the southern rim of the hedge.

Many reports note that the dynamics of small mammals are not only influenced by the reproductive output within the sampled plot, but also by adjacent agriculturally used areas (KIKKAWA 1964; POLLARD and RELTON 1970). Especially the removal of the shelter by harvesting the fields may force small mammals to invade hedges from the adjacent fields, which may be one factor contributing to the density peak during autumn. *A. sylvaticus* is known to use cultivated fields as foraging and breeding sites during summer, but immigrate into nearby woodlands or hedges during autumn (KIKKAWA 1964; POLLARD and RELTON 1970; GREEN 1979; PELZ 1979). Furthermore many plants produce their fruits and seeds during autumn and generate a good food resource within the hedge, which may attract mammals.

In addition to shelter and food resources, social interactions influence the dynamics of small mammal populations. Investigations by WATTS (1969), FLOWERDEW (1974, 1985), GURNELL (1978) and MONTGOMERY (1980) showed that intraspecific and density-dependent mechanisms influence populations of *A. sylvaticus*. Thereby, agonistic and aggressive behaviour of adult males from the previous year prevents the recruitment of subadults (either from the reproductive output within or from adjacent areas) into the breeding population in late spring and summer, thus keeping the total population stable until most of the old males have died at the end of the summer. Figure 1 seems to support this hypothesis: during summer there was a stable population and the recruitment of new individuals increased during August and September.

In summary beside reproduction within the hedge we have at least three further mutually non-exclusive explanations for the rodent peak during autumn: 1. invasions from agricultural areas; 2. local concentration at good food resources and 3. relaxation of intraspecific competition. It is a serious drawback of our study that we did not record information about the temporal change of food resources as well as the reproductive output within the hedge and adjacent areas to decrease the possible factors explaining the temporal pattern of rodent density within our hedge. One indication comes from the observation that the rodent density within our hedge was comparatively high. For example, NIETHAMMER (1978) reported maximum densities of about 60 individuals ha^{-1} for *A. sylvaticus*. The high densities found within our hedge supports the idea of favourable food resources. One of the ultimate reasons for this observation may derive from an "edge effect". Compared to forests a hedge has much longer boundaries to the surrounding habitats with favourable growing conditions for a wide variety of plants. Furthermore, this edge effect may allow the coexistence of *A. sylvaticus* and *A. flavicollis* in autumn. We observed a positive correlation between both species (Fig. 1), whereas numerous papers report some competition between these two species (e.g. SCHRÖPFER et al. 1984).

The average weight of all four rodent species indicates that mainly adults left the hedge, where they had first been caught. This finding contrasts with the age structure normally found among dispersing small mammals (GIPPS 1985; GAINS and MCCLENAGHAN 1980; WATTS 1970; WOLTEN and FLOWERDEW 1985). However investigations of KOZAKIEWICZ and Jurasinska (1989) on the recolonization of a woodlot by *C. glareolus*, surrounded by a 30 m-wide stripe of meadow, revealed that the average weights and the proportion of sexually active animals of the colonizing animals were higher than in the control population from a nearby forest. For *A. sylvaticus* the preponderance of adult males that moved to adjacent hedgerows might reflect competition or aggression existing between the males within a hedge population (see also Gipps 1985; Montgomery and Gurnell 1985; Wolton 1985).

77 % of all movements (N = 48) were observed among hedges, located within 40 m to each other, thus being well within the range that individuals traversed inside our main hedge during one night (unpubl. obs.). The facts, however, that animals had to cross rather open area when leaving the hedge and that they did not return to their original hedge (with two exceptions), seem to classify these movements not only as excursions or sorties but as true dispersal (Wolton and Flowerdew 1985). Compared to investigations on the dispersal of rodents in woodlands (Watts 1969, 1970), fluctuations of individuals in hedges seems to be rather high. This underlines the possible importance of hedges as corridors for a faunal exchange between fragmented remnants within our landscapes.

Zusammenfassung

Die Kleinsäugerfauna einer Feldhecke in Nordostbayern

Zwischen März und Dezember 1988 wurde die Kleinsäugerfauna einer Feldhecke nahe Bayreuth in Oberfranken untersucht. Mittels Lebendfallen konnten 5 Nagerarten sowie 4 Insektenfresserarten nachgewiesen werden. Häufigkeit und Artenzahl der Nager zeigte im Herbst einen Höhepunkt. Die Dichte lag dabei über den Vergleichswerten in der Literatur. Die häufigste Art war *Apodemus sylvaticus* (mehr als 300 Individuen ha^{-1}). Die Attraktivität der Fallen war bei dichter Umgebungsvegetation sowie am Südrand der Hecke am besten. Zwischen benachbarten Hecken konnte ein reger Individuenaustausch festgestellt werden.

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